PART I - ADMINISTRATIVE

Section 1. General administrative information

Title of project
Snake River Temperature Control Project, Phase III

BPA project number: 20142
Contract renewal date (mm/yyyy): ☐ **Multiple actions?**

Business name of agency, institution or organization requesting funding
Columbia River Inter-Tribal Fish Commission, University of Idaho, Oregon Graduate Institute

Business acronym (if appropriate) CRITFC, UI, OGI

Proposal contact person or principal investigator:

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NPPC Program Measure Number(s) which this project addresses
5.1A.1, 6.1D.7, 7.5B.3

FWS/NMFS Biological Opinion Number(s) which this project addresses
VI.A.1.b.4), VI.A.1.c.2, Incidental Take statement 17

Other planning document references
Wy-kan-ush miwa-kish-wit

Short description
Accurate characterization of Lower Snake River temperatures correlated with adult fall chinook salmon and steelhead passage and spawning success, and development of a flow/temperature management plan to maximize benefits of providing cooler water.

Target species
Fall chinook salmon
Steelhead

Section 2. Sorting and evaluation

Subbasin
Lower Snake Mainstem

Evaluation Process Sort

CBFWA caucus	Special evaluation process	ISRP project type
Mark one or more	If your project fits either of these	Mark one or more categories

caucus	processes, mark one or both	
☒ Anadromous fish ☐ Resident fish ☐ Wildlife	☒ Multi-year (milestone-based evaluation) ☐ Watershed project evaluation	☐ Watershed councils/model watersheds ☐ Information dissemination ☐ Operation & maintenance ☐ New construction ☒ Research & monitoring ☒ Implementation & management ☐ Wildlife habitat acquisitions

Section 3. Relationships to other Bonneville projects

Umbrella / sub-proposal relationships. List umbrella project first.

Project #	Project title/description

Other dependent or critically-related projects

Project #	Project title/description	Nature of relationship
	Lower Columbia River Adult Passage Project	Overlaps with Corps project which is tagging 1000 fall chinook to measure fallback and survival rates

Section 4. Objectives, tasks and schedules

Past accomplishments

Year	Accomplishment	Met biological objectives?

Objectives and tasks

Obj 1,2,3	Objective	Task a,b,c	Task
1	Develop a next-generation monitoring and modeling system for the Snake River Basin.	a	Implement a tri-level thermograph monitoring system in the Lower Snake River.
		b	Pilot integration of detailed monitoring and modeling for the Little Goose reservoir
		c	Development of a real-time monitoring and modeling system for the Snake River Basin
2	Characterize temporal and 3D spatial variability of temperature as a function of	a	Simulate flow and temperature distribution for actual hydrosystem operations for the duration of the project.

	hydrosystem operations		
		b	Characterize model biases and uncertainties
		c	Relate occurrence and characteristics of cooler corridors and pools to seasonality and hydrosystems operation
3	Characterize migration of adult fall chinook migrating through the Snake River.	a	Tag Snake River chinook and steelhead at Ice Harbor, Bonneville and Lower Granite dams with temperature and depth-sensitive radio tags
		b	Monitor passage of radio tagged fish through the lower Snake River.
		c	Relate salmonid behavior to temperature distributions.
4	Explore management options to enhance fall chinook salmon behavior	a	Simulate flow and temperature distribution for a range of scenarios of hydrosystem exploration
		b	Contrast occurrence and characteristics of bulk reservoir temperatures and cooler corridors and pools for the various scenarios hydrosystems operation
		c	Promote the development of consensus planning for strategies that improve migration of adult salmonids.

Objective schedules and costs

Obj #	Start date mm/yyyy	End date mm/yyyy	Measureable biological objective(s)	Milestone	FY2000 Cost %
1	10/1999	9/2003	Develop a next-generation monitoring and modeling system for the Snake River Basin.	Installation of tri-level thermographs	43.00%
2	10/1999	9/2003	Characterize temporal and 3D spatial variability of temperature as a function of hydrosystem operations		26.00%
3	10/1999	9/2003	Characterize migration of fall chinook migrating through the Snake River.	50-60 fall chinook and steelhead tagged per year	31.00%
4	11/2000	9/2003	Explore management options to enhance fall chinook salmon behavior		0.00%
					0
				Total	100.00%

Schedule constraints

Tagging schedule may be constrained by the schedule of releases of cold water from Lower Dworshak.

Completion date

FY 2003

Section 5. Budget

FY99 project budget (BPA obligated): $0

FY2000 budget by line item

Item	Note	% of total	FY2000
Personnel		%6	35,100
Fringe benefits		%2	11,056
Supplies, materials, non-expendable property		%0	1,000
Operations & maintenance		%0	0
Capital acquisitions or improvements (e.g. land, buildings, major equip.)	Archival transmitters	%0	0
NEPA costs		%0	
Construction-related support		%0	
PIT tags	# of tags:	%0	
Travel		%1	5,000
Indirect costs		%3	19,245
Subcontractor	University of Idaho-Radio Tagging	%20	114,198
Subcontractor	Oregon Graduate Institute	%44	250,692
Subcontractor	Mal Karr	%1	3,200
Subcontractor	University of Idaho-Monitoring	%21	120,000
Subcontractor	Scientist	%1	5,000
Other		%0	
		TOTAL BPA FY2000 BUDGET REQUEST	$564,491

Cost sharing

Organization	Item or service provided	% total project cost (incl. BPA)	Amount ($)
USGS	Salary for Dr. Ted C. Bjornn	%2	10,000
		%0	
		%0	
		%0	
		Total project cost (including BPA portion)	$574,491

Outyear costs

	FY2001	FY02	FY03	FY04
Total budget	$635,102	$579,453	$394,861	

Section 6. References

Watershed?	Reference
☐	Baptista, A.M., M. Wilkin, et al. 1998. Towards a multi-purpose forecast system for the Columbia River estuary. Ocean Community Conference '98, Baltimore, Maryland. 6 pp.

☐	Bennett D. et al. 1997. Thermal and velocity characteristics in the lower Snake River reservoirs, Washington, as a result of regulated upstream water releases. U.S. Army Corps of Engineers final completion report. Project 14-16-0009-1579. 178 pp.
☒	Bjornn, T.C. and five authors. 1998. Passage of chinook salmon through the lower Snake River and distribution into the tributaries, 1991-1993, Part 1 of final report. University of Idaho for U.S. Corps of Engineers and Bonneville Power Adminstration.
☐	Blumberg, A.F., and G.L. Mellor, 1995. A description of a three-dimensional coastal ocean circulation model. In Three-Dimensional Coastal Ocean Models, v. 4, N. Heaps, ed., AGU, 1-16.
☐	Karr, M. H. 1992. Snake River water temperature control project, 1992 operations and results. Summary report. Columbia River Inter-Tribal Fish Commission, Portland, OR.
☐	Karr, M. H. 1993. Snake River water temperature control project, 1993 operations and results. Summary report. Columbia River Inter-Tribal Fish Commission, Portland, OR.
☐	Karr, M. H., B. Tanovan, et al. 1992. Snake River water temperature control project interim report: Model studies and 1991 operations. Columbia River Inter-Tribal Fish Commission, U.S. Army Corps of Engineers, University of Idaho.
☐	Lynch, D.R., Ip, J.T.C., Naimie, C.E., and F.E. Werner. 1996. Comprehensive Coastal Circulation Model with Application to the Gulf of Maine, Continental Shelf Research, 16(7), 875-906.
☐	McKenzie S., 1998. Assembly and Review of Available Continuous Temperature Data, Columbia/Snake River Mainstem Water Temperature Workshop, Portland Conference Center, Dec. 3-4, Abstract.
☐	Yearsley J. and K. Whilden, 1998. Description of Temperature Assessment Model, Columbia/Snake River Mainstem Water Temperature Workshop, Portland Conference Center, Dec. 3-4, Abstract.

PART II - NARRATIVE

Section 7. Abstract

Enhanced understanding of temperature effects on fish migration is critical to the effective and ecologically sound management of the Columbia/Snake hydrosystem. We hypothesize that:

H1: Natural and operationally induced thermal stratification create cooler-water features in reservoirs that are of significance to adult migrants, particularly fall chinook salmon in the Lower Snake River (LSR).

H2: Management of thermal stratification is a feasible and effective complement to maintaining bulk reservoir temperature below pre-determined limits.

H3: Technology exists to develop integrated monitoring and modeling systems able to reliably guide the management of thermal stratification towards improved fish passage.

To evaluate H1 and H2, we propose to investigate the 3D spatial distribution of temperature in the LSR and to enhance understanding of the response of fall chinook salmon to this distribution. In the process, we will demonstrate H3.

Temperature distribution will be described through integrated real-time monitoring and modeling. Monitoring will include tri-level thermograph observations, complemented by higher-density thermistor chains. Ancillary meteorological and flow data will also be collected. Modeling will use numerical solutions of flow and heat balance equations, resulting in 3D descriptions of water levels, velocities and temperatures.

Fish behavior will be determined by radio tagging and monitoring migration of fall chinook salmon and steelhead throughout the LSR. Tags will record temperatures and depths experienced by migrating fish. Migration information will be correlated in space-time with temperature distributions from system-wide modeling and monitoring. This correlation will be used with scenario modeling to explore enhancement of fish passage through hydrosystem management.

Section 8. Project description

a. Technical and/or scientific background

The Snake River was once an important producer of Columbia Basin salmon and steelhead. However, runs of anadromous Snake River fish have greatly declined over the past century to the point where coho salmon runs are extinct, spring-summer chinook, fall chinook, and sockeye salmon are all listed as endangered under the Endangered Species Act, and steelhead are proposed for listing. A major problem faced by salmonids migrating both upstream and downstream in the summer and early fall are high water temperatures. The Snake River Water Temperature Project was initiated to determine if cool water from Dworshak Reservoir could be used to reduce temperatures in the LSR. In Phase I of this project, the U.S. Army Corps of Engineers funded the establishment of a water temperature and velocity monitoring network in the LSR (Karr et al. 1992, Karr 1992, Karr 1993, Bennett et al. 1997). Phase I, which quantified the physical capability to reduce water temperatures in the LSR using cold water releases, is now complete (Karr et al. 1992, Bennett et al. 1997).

In Phase II of the Snake River Water Temperature Control Project, funded by the U.S. Environmental Protection Agency and National Marine Fisheries Service, water temperature data drawn from Phase I was examined along with adult fish movement data. Hypotheses were developed regarding the effect of water temperatures on adaptive behaviors, survival, and spawning success. Available data on adult salmon and steelhead were applied to test hypotheses on the association between adult salmon and water temperatures. Karr et al. (1998) concluded that water temperatures at hydroelectric projects of the Columbia River and the LSR have often exceeded the incipient lethal temperature level of 20°C (68°F) for salmon and steelhead during July, August, and September. Water temperatures often are much higher during those months than they were historically due to reduced flows caused by irrigation withdrawals and storage, and the “heat sink” effect of Snake River reservoirs. Karr et al. (1998) also concluded that there was evidence to link LSR water temperatures with increased survival of migrating adult fall chinook salmon and a reduction in the period required for migration through the LSR. However, there was insufficient data to precisely describe the temperature structure of the LSR following cool water releases, or the effect on salmonid behavior. Questions such as the following remained unanswered: Can Dworshak Dam releases be used to maintain a corridor of cooler water through the LSR, and would the fish use it? And how long would pockets of cold water exist in the reservoirs after cold water releases stopped? Would fish remain in these pockets until another Dworshak cold water release? If these questions could all be answered in the affirmative, it may be possible to move fish through the LSR entirely in cooler water with periodic releases from Dworshak Dam.

This proposal describes Phase III of the Snake River Water Temperature Control Project. This project combines a field program to monitor water temperatures with an adult fall chinook salmon telemetry program (Karr et al. 1998). The objective of this project is to put in place a data collection and analysis program that permits understanding of the association between fish behavior and water temperatures during adult migration. This program, by comparing water temperature profiles with the migratory pathways chosen by the fish for their upstream migration through the LSR reservoirs, will improve fish management capabilities. It can provide the basis for management decisions on future water temperature control actions. A real-time temperature monitoring system will provide managers with immediate data on the response of the system to any temperature control effort. Models to be developed in Phase III will allow managers to accurately predict these responses prior to implementation. Such models, predicting temperatures in the LSR from inputs to the system and air temperatures, could allow better prioritizing of cool water releases from Dworshak Reservoir.

b. Rationale and significance to Regional Programs

The 1994 Fish and Wildlife Program states that the region should "initiate an annual policy and technical process to address flow and temperature regimes." (5.1A.1). Furthermore, measure 6.1D.7 calls for "additional salmon and steelhead migration studies, and coordinate with ongoing fish migration and behavior studies, such as timing, movement, fallback, straying and other characteristics. Report results to the Council annually." Finally, measure 7.5B.3 states that we should "continue to fund basic life history studies for Snake River fall chinook. This study should identify the range, limiting factors, effects of flow, temperature, spawning and rearing habitat, and migratory behavior."

High water temperatures, and their impact on migration, are recognized in the 1994 Fish and Wildlife Program as possible impediments to the recovery of Snake River salmonids, particularly fall chinook salmon. This study will increase our knowledge of the impact of high water temperatures on Snake River fall chinook salmon. From the temperature monitoring portion of this project, we will obtain a 3D spatial distribution of water temperatures in project reservoirs, and how this distribution relates to inflows, particularly cold water releases from Dworshak Dam. From the radio telemetry portion of this project, we will learn the paths fish use through the LSR and temperatures they are exposed to in relation to available temperatures in the reservoirs. Furthermore, we may also learn the best way to modify LSR temperatures to benefit fish passage.

NMFS biological opinion VI.A.1.c.2 recognizes that steelhead and chinook salmon are affected by late summer Snake River water management actions which result in high temperatures. Incidental Take Statement (ITS) 17, as referenced in opinion VI.A.1.b.4 calls for "monitoring river temperatures, and implementing, when possible temperature control measures in the LSR such as releasing cool water from Dworshak Dam and Hells Canyon complex." ITS 17 recognizes that high water temperatures "negatively affect the life history of salmonids", and that decreased water temperatures "may reduce stress and contribute to greater passage and spawning success for chinook salmon, sockeye salmon, and other anadromous species." ITS 17 also calls for upgrading water temperature prediction models and expanding the existing water temperature monitoring network in the LSR.

The Tribal Recovery Plan, Wy Kan Ush Me Wa Kush Wit, recognizes that high Columbia and Snake River mainstem temperatures are detrimental to adult migrants. The plan calls for releases from Dworshak and Brownlee Dam for use during July, August, and September to provide cool water flow augmentation for adult Snake River fall chinook and steelhead. The plan also calls for continued monitoring the effects of cool water releases, development of the models of LSR water temperatures, and analyzing the correlation between cool water flow augmentation and reductions in migration time, interdam losses, and increases in spawning success.

c. Relationships to other projects

The monitoring portion of this project complements present Corps of Engineers scrollcase, dissolved gas network, and tri-level thermograph temperature monitoring. Deploying and maintaining these devices may require the cooperation and/or assistance of the Corps of Engineers. The modeling portion of the project partially overlaps with on-going modeling efforts for the Snake River by the Environmental Protection Agency (e.g. Yearsly and Whilden 1998) and the Corps of Engineers. However, none of these efforts involve real-time forecasts nor do they include system-wide 3D modeling. As a part of this project, we will seek to develop inter-model comparison arrangements with those agencies.

The modeling portion of this project uses similar concepts and tools, and the same modeling group, used by the on-going project Ocean Survival Of Juvenile Salmonids In The Columbia River Plume (M. Schiewe, NMFS, Principal Investigator. The project measures the effects of time of entry and smolt quality, food habits, growth, and bioenergetic status of juvenile coho and chinook salmon on survival in relation to oceanographic features of the nearshore ocean environment associated with the Columbia River.

Outfitting fall chinook salmon with transmitters will be conducted by personnel from the University of Idaho in association with the Lower Columbia River Adult Passage Project and will require access to trapping facilities at Bonneville and Ice Harbor dams. Collection of fall chinook salmon with tags, downloading tags, and the collection and outfitting of adult steelhead with transmitters at Lower Granite Dam adult trap will be conducted by NMFS personnel, with assistance from University of Idaho personnel. The radio tracking portion of this project could complement other Snake River research projects. We will gain permission from the appropriate researchers prior to outfitting PIT-tagged salmon and steelhead with transmitters. Similar studies previously conducted by the University of Idaho with PIT-tagged salmon and steelhead have been supported by other researchers.

We will seek the cooperation of water management agencies to provide water releases during periods in which both temperature monitoring equipment is stationed in the LSR and radio-tagged fish are in the LSR. Prior to the start of the adult migration, we will invite input from various agencies at technical and public forums. Throughout this project, we will provide water management agencies with real time data on water temperatures and movement of radio-tagged fish. As a predictive model of LSR water temperatures is developed, it will be available for use by water management agencies.

d. Project history (for ongoing projects)

n/a

e. Proposal objectives

1. **Develop a next-generation temperature monitoring and modeling system for the LSR.**
Rationale and approach: We hypothesize that the technology exists to develop an integrated monitoring and modeling system for temperature that can reliably guide management of the Snake Basin hydrosystem towards improved fish migration. We propose to develop such a system in progressive steps. The first step is resuming and expanding an historical network of tri-level thermograph observations. The second step is developing a pilot monitoring and modeling network for a single reservoir (Little Goose), emphasizing the detailed description of 3D temperature distribution. The third step is to extend, with necessary adjustments, the concepts and tools of the pilot project to real-time and to the Snake River Basin. Step 1 will guarantee the availability, throughout the project, of system-wide temperature data for correlation with fish studies. Step 2 will both demonstrate the feasibility of detailed 3D descriptions of temperature distributions and permit an objective assessment of what aspects of that description can be simplified. Step 3 will provide the support tool required by Objectives 2-4.
Tasks:
1a. Implement a tri-level thermograph monitoring system in the LSR.
1b. Pilot integration of detailed monitoring and modeling for Little Goose reservoir
1c. Development of a real-time monitoring and modeling system for the LSR

2. **Characterize temporal and 3D spatial variability of temperature as a function of hydrosystem operations**
Rationale and approach: We hypothesize that natural and operationally induced thermal stratification create cooler-water corridors or pools deep in reservoirs that are of significance to adult migrants, particularly fall chinook salmon in the LSR. Here we focus on the first part of this hypothesis (Objective 3 addresses the second part). We will use the proposed modeling system to simulate time histories of spatially detailed temperature distribution in the Snake Basin for the duration of the project. After evaluating and minimizing model errors and uncertainties by contrast with

observations, we will use the model simulations to identify and characterize cooler corridors and pools as a function of season and hydrosystem operation.

<u>Tasks:</u>

2a. Simulate flow and temperature distribution for actual hydrosystem exploration for the duration of the project

2b. Characterize model biases and uncertainties

2c. Relate occurrence and characteristics of cooler corridors and pools to seasonality and hydrosystems operation .

3. **Characterize migration of salmonids through the LSR during periods of high temperature.**

<u>Rationale and approach:</u> Characterizing the migration of fish relative to temperature distributions is essential to determine whether fish is able to take advantage of thermal corridors. We propose to characterize migration during August and September by tagging fish at Bonneville and Ice Harbor (fall chinook salmon) dams and at Lower Granite dam (steelhead) using temperature and depth-sensitive radio tags. Passage of tagged fish will be monitored through the LSR. Temperature and depth data from the tags will be used in conjunction with temperature data and simulations (Objective 2) to establish migration patterns and to determine whether fish effectively take advantage of thermal corridors when available.

<u>Tasks:</u>

3a. Tag Snake River fall chinook salmon at Ice Harbor and Bonneville dams, and steelhead at Lower Granite Dam with temperature and depth-sensitive radio tags.

3b. Monitor passage of radio tagged fish from Bonneville, Ice Harbor, and Lower Granite dams through the LSR.

3c. Relate fall chinook salmon behavior to temperature distributions

4. **Explore management options to improve salmonid migration during periods of high temperature**

<u>Rationale and approach</u>: Most efforts to improve temperature-related aspects of salmonid migration have been based on bulk reservoir temperature. We hypothesize that the management of thermal stratification is a feasible and effective complement to maintaining bulk reservoir temperature below pre-determined limits. To test this hypothesis, we first simulate flow and temperature distribution for a range of scenarios of hydrosystem operations during August and September. We will then contrast occurrence and characteristics of bulk reservoir temperatures and cooler corridors and pools for the various scenarios. This contrast, and understanding of fish response to temperature distributions, will be used to promote the development of inter-agency consensus planning of strategies that balance other water uses with improved salmonid migration during periods of high temperature.

<u>Tasks:</u>

4a. Simulate flow and temperature distribution for a range of scenarios of hydrosystem operations.

4b. Contrast occurrence and characteristics of bulk reservoir temperatures and cooler corridors and pools for the various scenarios of hydrosystems operation.

4c. Promote the development of consensus planning for strategies that improve migration of fall chinook salmon.

f. Methods

Objective 1: Develop a next-generation temperature monitoring and modeling system for the LSR

Task 1a. Implement a tri-level thermograph monitoring system in the LSR. (years 1 through 4)

The monitoring backbone will be constituted by a minimum of 12 tri-level thermograph stations, which will operate during the juvenile and adult migratory period in the four lower Snake Reservoirs. Hourly water temperatures will be downloaded from recording thermographs at monthly intervals, except from

July through September when downloading would occur at semi-monthly intervals. Alternatives for real-time data acquisition (e.g., satellite and radio frequency telemetry) will be explored.

Task 1b. Pilot integration of detailed monitoring and modeling for the Little Goose reservoir (year 1)

The time evolution of the 3D temperature distribution in the Little Goose reservoir will be described through tight integration of monitoring and modeling.
Monitoring will be designed to supplement existing monitoring programs for water temperature (project scroll cases, dissolved gas network, USGS network, etc), discharges and meteorological parameters. Our monitoring backbone will be constituted by the three tri-level thermograph stations proposed for the reservoir (Task 1a). Important additional spatial detail will be provided by eight thermistor chains, each densely populated in the vertical (sensors every 0.25-1 m in the vertical). Three of these chains will be co-located with the tri-level thermograph stations, both for cross-calibration and to augment a valuable historical data set. The remaining chains will be installed at the forebay wall of Little Goose (3), strategically distributed in the horizontal) and in the tailwater wall of Lower Granite (2). Driven both by data interpretation and model assessment needs, we will also monitor wind and air temperature at least in one station, and vertical profiles of water velocity and backscatter at one location. QA/QC protocols will be established based on our experience in other systems and on explicitly sought-out regional consensus.

Modeling will be based on 3D numerical solutions of flow and heat balance equations, resulting in spatial and temporal descriptions of water levels, velocities, temperatures, and surface heat fluxes. We will inter-compare at least two 3D codes (Blumberg and Mellor 1987 and Lynch et al. 1995), both of which are available in the public domain and have been used by Baptista and co-workers. Model simulations will be conducted for grids with various spatial resolutions, including a reference grid of O(100-1000m) refinement along the longitudinal axis, O(10-100m) along the cross-section, and O(0.5-1m) in the vertical. Data assimilation will be likely be used to optimize model performance. Prior to data assimilation, however, the reference grid simulations and the monitoring program will enable us to evaluate, for coarser grids and likely for lower-dimensionality models, both error bounds and loss of ability to characterize cooler corridors and pools. We will seek to cooperate with EPA and the Corps of Engineers in model inter-comparison and other aspects of the modeling effort.

During this pilot demonstration we will test various alternatives for real-time data acquisition (e.g., satellite and radio frequency telemetry), based both on our experience with the CORIE network and on exploring possible leverage with local systems already in place or planned. However, operational telemetry is planned only for Task 1c.
Data collected in this pilot demonstration will be integrated with data from other monitoring programs for temperature (project scroll cases, dissolved gas network, USGS network, etc.), discharges and meteorology, and with modeling simulations. To achieve this objective, we plan to rely on the web-based data management strategy and technologies developed in CORIE (Baptista et al. 1998, //www.ccalmr.ogi.edu/CORIE) for real-time and archival data, with adjustments and extensions required to be functionally compatible with DART.

Task 1c. Development of a real-time monitoring and modeling system for the LSR

This task consists on extending both the functionality and the regional extent of the Little Goose pilot system. The target domain in Year 2 and beyond is the entire LSR system from Ice Harbor dam to Dworshak and Hells Canyon dams, including inflow from major tributaries (Clearwater, Grande Ronde and Salmon rivers). Target functionality in Year 4 will include real-time access to data, and real-time forecasting of water levels, flows, and velocity and temperature distributions. Results of the Little Goose pilot project will, early in Year 2, be evaluated towards the design and implementation of the LSR. The paragraphs below only represent, therefore, preliminary concepts.

We anticipate targeting 3D modeling representations of velocity and temperature distribution for the entire the LSR system. However, we may resort to two-dimensional (longitudinal axis and vertical) representations in sub-parts of the system, if warranted by the physics and necessary for computational performance. The inter-model comparison proposed for Task 1b will not be carried through the present task, which for logistical reasons will require the choice of a single model. Spatial and temporal resolution will be as fine as computationally feasible and as warranted by the physics of the system. The monitoring strategy will, for each reservoir, be similar to that for Little Goose: the tri-level thermographs constitute the backbone, with thermistor chains providing supplemental horizontal and vertical detail. Limited meteorology (probably in permanence for each reservoir) and velocity and backscatter profiles (probably in two stations, rotating over time among reservoirs) will also be included. Telemetry will be based on our experimentation in Task 1b, and will probably be implemented only in Year 3. Integration of project data with model simulations and with other sources of data will follow the strategy outlined in Task 1b.

Objective 2: Characterize temporal and 3D spatial variability of temperature as a function of hydrosystem operations (Years 2-4)

Task 2a. Simulate flow and temperature distribution for actual hydrosystem exploration for the duration of the project

Once the modeling system proposed in Task 1c is developed (real-time capability not required), we will systematically simulate and archive at the water level, and velocity and temperature distributions for the LSR during the period of duration of the project. Archival will be in NetCDF, a machine-compatible, self-documented, binary-type format used by many modeling and monitoring communities. Results of these simulations will constitute a critical information database for our analysis of thermal stratification and its relation to fish migration (various other tasks of the project).

Task 2b. Characterize model biases and uncertainties

While Tasks 1b-c will involve evaluation of model performance against monitoring data and/or other models or different-resolution grids, emphasis will be on modeler-oriented analyses based on selected benchmark conditions. Here, we will characterize model biases and model and data uncertainties systematically for the entire period of the project, with the objective of supporting an informed use of the information by biologists and managers.

Task 2c. Relate occurrence and characteristics of cooler corridors and pools to seasonality and hydrosystems operation

Temperature and ancillary data and the archival model simulations from Task 2a will be analyzed qualitatively via two-dimensional and three dimensional graphics and animations, and quantitatively via statistics, correlation, and time-series analysis. The focus will be on determining whether and under what circumstance corridors or pools of cooler water with potential ecological significance are generated under current hydrosystem management. Emphasis will be on the months of August and September (for consistency with Objectives 3 and 4), but we may also examine at a cursory level the occurrence, cooling capacity, and persistence of local thermal features through the duration of the project, under normal hydrosystems operation.

Objective 3: Characterize migration of salmonids migrating through the LSR in August and September

Task 3a. Tag Snake Basin chinook and steelhead at Ice Harbor, Bonneville and Lower Granite dams with temperature and depth-sensitive radio tags

Temperature and depth-recording archival transmitters would be assembled by Lotek Engineering, Inc., Ontario, Canada. The order for tags will need to be made 6-9 months prior to start of tagging operations.

Fall chinook salmon will be collected from the south-shore ladder at Ice Harbor Dam, similar to procedures used in 1991 and 1992 (Bjornn et al. 1998). At Ice Harbor, fish are diverted from the fishway into the trap box, where they are observed and selected for tagging, or released and allowed to continue up the ladder. Salmon to be tagged will be anesthetized, outfitted with a transmitter inserted into the stomach through the mouth, and released into the Ice Harbor forebay. Transmitters used will capable of recording water temperature and fish depth. Tags will be recovered from Lyons Ferry Hatchery and from the adult trap at Lower Granite Dam so that data can be downloaded. Recovered tags will be returned to Ice Harbor Dam to be placed into another fish. We hope to be able to use 25 tags in at least two fish each, for a total of 50 fish to be tagged at Ice Harbor Dam.

Salmon tagged at Ice Harbor Dam will be augmented with fish collected from the Bonneville Dam. The procedure for collecting and tagging chinook salmon at Bonneville Dam will be similar to that used in 1996, 1997, and 1998. Fish are diverted from the north-shore fishway into the Fisheries Engineering Research Laboratory (FERL) bypass ladder and into the FERL facility. Fish then swim into exit chutes from which they can be diverted into an anesthetic tank (MS-222) via electronically controlled guide gates. A PIT-tag detector will be used to indicate when Snake River PIT-tagged salmon pass down the exit chutes. Anesthetized fish are moved to a smaller tank where scale samples are collected, lengths and presence of marks and injuries are recorded, and the fish are tagged. Each fish receives a coded wire tag injected into the muscle near the dorsal fin, a numbered visual-implant (VI) tag injected under the clear tissue posterior to the eye, and a radio transmitter inserted into the stomach through the mouth. PIT-tagged fish will be scanned with a hand wand connected to a computer which will be used to determine where fish were released as juveniles. Fall chinook salmon released as juveniles in the Snake River will receive archival transmitters and will be weighed. Tagging generally requires 3-6 min per fish and the fish are anesthetized and submerged at all times except when moved between tanks and when measured for length. After tagging, fish are moved to a 600 gal aerated tank on a trailer to recover for at least one hour. Fish are transported 8 km downstream from Bonneville Dam in the recovery tank and released at a boat ramp using an exit chute attached to the rear of the tank. Any tags recovered as the fish migrate upstream will be returned to Bonneville or Ice Harbor dams (depending on which is closer) for reuse in another fish. Fish that reach Lower Granite Dam will be weighed on a scale similar to that used at Bonneville Dam, scale samples collected, and the archival tags will be removed and the data downloaded. Weight lost by the salmon during their migration from Bonneville to Lower Granite Dam will be compared to migration rates, and water temperatures experienced by each fish. We hope to tag at least 10 to 20 Snake River fall chinook salmon at Bonneville Dam.

Transmitters will be pulled from fall chinook salmon and downloaded at the Lower Granite Dam adult trap because there is no similar location further upstream where fall chinook salmon can be collected. Thus, we propose using adult steelhead destined for Dworshak National Fish Hatchery as surrogates for fall chinook salmon passage through Lower Granite Reservoir. A sort-by-code program will be used to divert PIT-tagged steelhead into the trap. Steelhead will be anesthetized (MS-222) and scanned with a hand wand connected to a portable computer to determine where the fish was released as a juvenile. Steelhead destined for Dworshak Hatchery will be outfitted with archival transmitters placed in their stomach through the mouth, and they will be released into the fish ladder. We hope to be able to outfit at least 20 steelhead with transmitters, some of which will be with tags recovered from fall chinook salmon that passed through the adult trap.

Task 3b. Monitor passage of radio tagged fish through the LSR.

Movements of chinook salmon and steelhead through the LSR will be monitored using a combination of fixed-site receivers and by mobile tracking by truck and boat. Radio receivers will be located at LSR dams, reservoirs, and mouths of tributaries. The minimal set-up at the four LSR dams would consist of one or two SRX receivers connected to aerial antennas in the tailraces and an SRX/DSP receiver connected to an underwater antenna at each of the ladder exits at the tops of the dams. Antennas are currently in place at these sites but may require general maintenance prior to the 2000 field season. More receivers and antenna may be used to monitor use of fishway entrances and passage through fish ladders at one or more of the LSR dams, depending on other studies ongoing at the projects. Receiver sites with aerial antennas will be located on the river bank about mid-way along the length of each of the four reservoirs. Receiver sites used in the past at tributary mouths will be used during this study. Sections of the LSR will be periodically mobile-tracked by truck or boat to locate fish with transmitters between fixed-site receivers.

Data recorded on receivers will be periodically downloaded to portable computers and transferred to the database maintained at the NMFS office in Seattle, WA. Data will be processed and analyzed following completion of the migration seasons and University of Idaho. Fish movement patterns, migration rates, and temperature and depth data will be summarized and correlated to water temperatures recorded from each reservoir.

Task 3c. Relate salmonid behavior to temperature distributions.

Using the temperature and depth information from the fish tags, and the time-evolving three-dimensional temperature distributions provided by the integrated monitoring and modeling network (Tasks 1c and 2a-c), we will attempt to re-construct the space-time migration path of the tagged fish (Tasks 3a-b) within each reservoir, and thus enhance understanding of the extent to which fish can take advantage of thermal stratification to enhance its migration conditions. We will also attempt to evaluate energy used by these fish as they migrated upstream, from weight lost during their migration through the reservoirs. Energy use will be correlated with passage times and water temperatures experienced by each fish.

Objective 4: Explore management options to improve salmonid migration during periods of high temperature

Task 4a. Simulate flow and temperature distribution for a range of scenarios of hydrosystem exploration

Using models developed in Task 1c, we will simulate August and September temperature distributions throughout the system, resulting from selected alternative scenarios of hydrosystem management with potential to enhance migration of fall chinook and/or steelhead. Examples could include timed water releases from Dworshak, selective changes in withdrawal depth, and perhaps dam removal. As a part of the scenario selection process, we will seek opinions through input from the advisory board and one or more workshops from a cross-range of interested parties on management alternatives favored or considered realistic by those parties.

Task 4b. Contrast occurrence and characteristics of bulk reservoir temperatures and cooler corridors and pools for the various scenarios hydrosystems operation

We will systematically compare the simulations generated in Tasks 2a (actual system conditions) and 4a (alternative management scenarios), in an attempt to address questions of the type:

What changes would be required in hydrosystems operation to induce or modify the type of thermal features that could benefit salmonid migration?

What would be the implications of any recommended operational change on the year-long physical characteristics of the reservoir (e.g., total water storage, depletion of cool water reserves, etc.)?

Task 4c. Promote the development of consensus planning for strategies that improve salmonid migration.

In Year 4, we will organize a series of three workshops open to broad multi-agency participation. The first workshop will introduce the LSR monitoring and modeling system, with emphasis on a discussion of capability and limitations, including inter-comparison with (and perhaps integration of) other models available for the region and real-time capabilities. The desired outcome, prepared through progress reports and small-group modeling meetings conducted in earlier years, will be to arrive at a regional consensus on the value, uncertainties, and operation of the LSR monitoring and modeling system as an institutionalized management-support tool. The second workshop will focus on the relationship between temperature and fish behavior. The desired outcome is a peer-review of the understanding of temperature-fish behavior relationships derived in the project and a regional consensus on whether thermal stratification opens new management opportunities relative to bulk reservoir temperatures. The third workshop will explore the impact on fish (fall chinook and steelhead) migration of alternative hydrosystem operations, both through archival data (Task 4b) and through on-site simulations for participant-driven scenarios. The desired outcome is a consensus recommendation to the Bonneville Power Administration on hydrosystem management strategies.

g. Facilities and equipment

Objective 1

Task 1a: Personnel from the University of Idaho will maintain the tri-level thermographs, re-occupying historical stations and extending those stations to at least three per reservoir. The field infrastructure is in place for this operation. Telemetry for all stations and thermographs for the extra stations and associated materials and supplies will need to be purchased.

Task 1b-c: OGI personnel will build the thermistor chains, and the frames necessary for the deployment of bottom-mounted Acoustic Doppler Profiler (ADP) and for mounting the wind and air temperature gauges. Two ADP's (one each in Years 1 and 2) will be purchased by OGI. Except for the pilot Little Goose demonstration (where existing equipment will be used), wind and air temperature gauges will also be purchased by OGI. OGI personnel will conduct the installation of the thermistor chains, ADP and meteorological station in Year 1, with the assistance of personnel and vessel infrastructure from the University of Idaho. Field installations (beyond Year 1), maintenance, and data retrieval will be primarily conducted by personnel and with vessel infrastructure from the University of Idaho, in coordination with OGI personnel. Telemetry will be designed jointly by OGI and University and Idaho, and will be purchased and installed by the latter. The computer resources available at OGI are sufficient for the modeling and data analysis required for these tasks.

Objective 3

Personnel from the University of Idaho will need access to the trapping facility and equipment at the south-shore ladder at Ice Harbor Dam. Equipment will be similar to that used to collect chinook salmon from Ice Harbor Dam in 1991 and 1992. Some maitenance and fabrication will likely be required. Trapping will involve placing diversion screens, a trap box, and holding pen in the ladder daily and will require use of a crane at the facility to move trap parts ands remove the holding pen containing the salmon to be tagged. Trapping would occur from about mid-August until the end of October, or until sufficient numbers of fish had been tagged for the study. Access to the FERL facility will be needed to continue tagging operations at Bonneville Dam. Installation and activation of the PIT tag detector will be needed to allow selection of Snake River fall chinook salmon at the facility. Other aspect of tagging operation will be similar to that of previous years. Collection of fall chinook salmon and tagging of steelhead at Lower Granite Dam will be conducted at the adult trap by personnel from NMFS and the University of Idaho, as in previous years. All transmitters will need to be purchased prior to start of tagging operations.

Personnel from the University of Idaho will need access to the tailraces and fishway ladders at Ice Harbor, Little Goose, Lower Monumental, and Lower Granite dams to allow maintenance of, and to periodically download data from receivers. Antennas are currently in place at these, and the tributary sites, but will need general maintenance prior to start of the 2000 field season. Additional aerial antennas, and associated hardware and receiver boxes, will need to be purchased and installed for the mid-reservoir receiver sites. We currently have a sufficient number of receivers for the proposed operations in 2000, barring requirements for other studies that may be added by then. A sufficient number of vehicles and computers, etc., are available for the proposed studies.

h. Budget

Personnel, travel, and supply costs cover CRITFC personnel required to assist in coordination of the project, and assist in the planning and implementation of both the temperature monitoring and radio tagging portion of the project. The University of Idaho Radio Tagging subcontract covers the cost of planning and implementing the radio tagging portion of the project. The Oregon Graduate Institute subcontract covers the temperature monitoring and temperature modeling portion of the project. The University of Idaho Monitoring subcontract covers the cost of installing and maintaining the tri-level thermographs in the LSR, as well as assisting in installing and maintaining other temperature monitoring equipment. The Scientist and Mal Karr portion of the budget are to provide assistance which may be needed in project coordination, planning, and implementation.

Section 9. Key personnel

Project Coordination

Jeff Fryer, CRITFC, Principal Investigator
Ted C. Bjornn, University of Idaho, Co-Principal Investigator
Antonio Baptista, OGI, Co-Principal Investigator
David Bennett, University of Idaho, Co-Principal Investigator
Mal Karr, Co-Principal Investigator

Planning and Implementation of Temperature Monitoring System

Antonio Baptista and Michael Wilkin, OGI
David Bennett and field aides, University of Idaho
Mal Karr
Jeff Fryer, CRITFC

Developing, Evaluating and Running Flow and Temperature Modeling System

Antonio Baptista, Post-Doctoral Research Associate and modeling aides, OGI

Preparation of radio tag study design

Ted C. Bjornn, University of Idaho
Chris Peery, University of Idaho
Jeff Fryer, CRITFC

Tagging at Bonneville Dam

Rudy R. Ringe, Steve Lee, and two biological aides, University of Idaho

Tagging at Ice Harbor Dam

Patrick Keniry, Chris Peery, and one biological aide, University of Idaho

Tagging at Lower Granite Dam

One biological aide, University of Idaho

Telemetry equipment specifications and purchasing

Ken Tolotti, University of Idaho

Monitoring receivers at dams, downloading data, general maintenance

Chris Peery, Pat Keniry, and biological aides, University of Idaho

Analysis of thermal structure and features

Antonio Baptista, Post-Doctoral Research Associate and modeling aides, OGI

Analysis of fish movement and correlation with temperature monitoring data

Ted Bjornn, Chris Peery, University of Idaho
Antonio Baptista, OGI
Jeff Fryer, CRITFC

Data Management

Ted Bjornn, Chris Peery, David Bennet and aides, University of Idaho
Antonio Baptista and aides, OGI

Coordination of workshops and preparation of project final report

Jeff Fryer, CRITFC
Ted Bjornn, Chris Peery, University of Idaho
Antonio Baptista, OGI

Vita of

Jeffrey K. Fryer

Education

1995 University of Washington. Ph.D. (Fisheries).

1985 University of New Brunswick at Fredericton, New Brunswick, Canada. MSc(Computer Science).

1979 University of New Brunswick at Fredericton. BSc(Computer Science) with the equivalent of an Honors in Statistics.

Publications

Fryer, J.K. 1998. Frequency of pinniped-scars and wounds on adult spring-summer chinook and sockeye salmon returning to Bonneville Dam. North American Journal of Fisheries Management. 18:46-51.

Fryer, J.K. 1995. Columbia Basin sockeye salmon-causes of their past decline, factors contributing to their present low abundance, and the future outlook. Ph.D. Thesis. University of Washington, Seattle.

Fryer, J.K. and P.R. Mundy. 1993. Determining the relative importance of survival rates at different life history stages on the time required to double adult salmon populations, p. 219-223. *In* R. J. Gibson and R.E. Cutting [ed.] Production of juvenile Atlantic salmon, *Salmo salar*, in natural waters. Canadian Special Publication in Fisheries and Aquatic Sciences 118.

Hatch, D.R., J.K. Fryer, M. Schwartzberg, and D.R. Pederson. 1998. A computerized editing system for video monitoring of fish passage. North American Journal of Fisheries Management. 18:694-699.

Schwartzberg, M. and J.K. Fryer. 1993. Identification of hatchery and naturally spawning Columbia Basin spring chinook salmon using scale pattern analyses. North American Journal of Fish Management. 13: 263-261.

Employment

October 1989 to present: Fisheries scientist at Columbia River Inter-Tribal Fish Commission. Duties have included participation in Phase II of the Snake River Temperature Project, being responsible for data management and participating in statistical analyses and the writing of the final report. Duties have also included supervision of CRITFC's stock identification projects, requiring designing and implementing stock identification experiments, field sampling, creating computer programs, spreadsheets, and databases to manage and analyze data, and publishing technical reports and journal articles.

September 1985 to September 1989: Graduate research and teaching assistant at the University of Washington. Duties included teaching an introductory computer course and assisting the teaching of statistics courses and calculus.

NAME: BJORNN, Theodore C.

POSITION: Professor of Fish Resources and Assistant Leader, Idaho Cooperative Fish and Wildlife Research Unit, College of Forestry, Wildlife and Range Sciences, University of Idaho, Moscow 83843. (208) 885-7617

EDUCATION

Degree	Date	Institution	Location	Major
B.S.	1956	Utah State U.	Logan, UT	Fish Biology
M.S.	1957	U. of Idaho	Moscow, ID	Fishery Mgt.
Ph.D.	1966	Utah State U.	Logan, UT	Fish Biology

RECENT EXPERIENCE

1985 - Present: Professor of Fish Management and Assistant Leader of Idaho Cooperative, Fish and Wildlife Research Unit, Department of Fish and Wildlife Resources, University of Idaho.

1973-1985: Professor of Fish Management and Leader, Idaho Cooperative Fishery Research Unit, Department of Fish and Wildlife Resources, University of Idaho.

1966-1973: Associate Professor of Fish Management and Assistant Leader, Idaho Cooperative Fishery, Research Unit, Department of Fish and Wildlife Resources, University of Idaho.

RELEVANT PUBLICATIONS

Stabler, D. F., R. R. Ringe, R. G. White, and T. C. Bjornn. 1975. The effects of altered flow regimes, temperatures and river impoundment on adult steelhead trout and chinook salmon. Idaho Cooperative Fishery Research Unit, University of Idaho, Progress Report, Moscow.

Irving, J. S., and T. C. Bjornn. 1981. Status of Snake River fall chinook salmon in relation to the Endangered Species Act. Idaho Cooperative Fishery Research Unit, University of Idaho, Moscow.

Stabler, D. F., R. G. White, R. R. Ringe, and T. C. Bjornn. 1981. Effects of altered flow regimes, temperatures and river impoundment on adult steelhead trout and chinook salmon. Forest, Wildlife and Range Experiment Station, University of Idaho, Final Report, Contribution 215, Moscow.

Bjornn, T.C., and C.A. Peery. 1992. A review of literature related to movements of adult salmon and steelhead past dams and through reservoirs in the lower Snake River. Technical Report 92-1. Idaho Cooperative Fish and Wildlife Research Unit, University of Idaho, Moscow.

Bjornn, T.C., M.A. Jepson, C.A. Peery, and K.R. Tolotti. 1997. Evaluation of adult chinook salmon passage at Priest Rapids Dam with orifice gates open and closed – 1996. Technical Report 97-1, Idaho Cooperative Fish and Wildlife Research Unit, University of Idaho, Moscow, Idaho.

Bjornn, T.C., K.R. Tolotti, J.P. Hunt, P.J. Keniry, R.R. Ringe, and C.A. Peery. 1998. Passage of chinook salmon through the lower Snake River and distribution in the tributaries, 1991-1993. Part I of final report for Migration of adult chinook salmon and steelhead past dams and through reservoirs in the lower Snake River and into tributaries. U.S Army Corps of Engineers, Walla Walla, Washington.

Bjornn, T.C., J.P. Hunt, P.J. Keniry, R.R. Ringe, and C.A. Peery. 1998. Entrances used and passage through fishways for salmon and steelhead at Snake River dams. Part III of final report for Migration of adult chinook salmon and steelhead past dams and through reservoirs in the lower Snake River and into tributaries. U.S Army Corps of Engineers, Walla Walla, Washington.

Bjornn, T.C., J.P. Hunt, P.J. Keniry, R.R. Ringe, and C.A. Peery. 1998. Turbine priority and its effects on passage of steelhead at Snake River dams. Part VI of final report for Migration of adult chinook salmon and steelhead past dams and through reservoirs in the lower Snake River and into tributaries. U.S Army Corps of Engineers, Walla Walla, Washington.

Bjornn, T.C., J.P. Hunt, P.J. Keniry, R.R. Ringe, and C.A. Peery. 1998. Movements of steelhead in fishways in relation to transition pools. Part V of final report for Migration of adult chinook salmon and steelhead past dams and through reservoirs in the lower Snake River and into tributaries. U.S Army Corps of Engineers, Walla Walla, Washington.

Bjornn, T.C., J.P. Hunt, P.J. Keniry, R.R. Ringe, and C.A. Peery. 1998. Effect of zero versus normal flow at night on passage of steelhead in summer and fall. Part VII of final report for Migration of adult chinook salmon and steelhead past dams and through reservoirs in the lower Snake River and into tributaries. U.S Army Corps of Engineers, Walla Walla, Washington.

Peery, C.A, T.C. Bjornn, and K.R. Tolotti. 1998. Evaluation of adult chinook and sockeye salmon passage at Priest Rapids and Wanapum dams with orifice gates open and closed and with a fishway fence – 1997. Technical Report 98-2, Idaho Cooperative Fish and Wildlife Research Unit, University of Idaho, Moscow, Idaho.

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Academic Training and Honors

1978 Engenheiro Civil, Academia Militar, Lisboa, Portugal

1984 Master of Science in Civil Engineering, Massachusetts Institute of Technology, Cambridge, Massachusetts, USA (Thesis title: Eulerian-Lagrangian Analysis of Pollutant Transport in Coastal Waters. Advisors: Prof. K.D. Stolzenbach and Dr. E. Eric Adams)

1986 Especialista em Hidráulica Maritima (Specialist in Maritime Hydraulics), Laboratório Nacional de Engenharia Civil-LNEC, Lisboa, Portugal

1987 Doctor of Philosophy in Civil Engineering, Massachusetts Institute of Technology Thesis title: Solution of Advection-dominated Transport by Eulerian-Lagrangian Methods Based on the Backwards Method of Characteristics. Advisors: Prof. K.D. Stolzenbach and Dr. E. Eric Adams)

Professional Experience

s. 1998 Professor, Department of Environmental Science and Engineering, OGI

s. 1991 Director, Center for Coastal and Land-Margin Research, OGI

1987/98 Assistant Professor then Associate Professor, Department of Environmental Science and Engineering, OGI

1979/87 Researcher, Estuaries Division, Hydraulics Department, Laboratório Nacional de Engenharia Civil (LNEC), Portugal: Assistant Researcher (79/86); Research Officer (86/87)

1979/80 Visiting Engineer, Laboratoire National d'Hydraulique, Chatou, France

Professional Affiliations and Activities

Affiliations: The Tsunami Society (s. 1993); Ordem dos Engenheiros, Portugal (s. 1993); American Society of Civil Engineers, ASCE (s. 1992); American Geophysical Union, AGU (s. 1986); Associação Portuguesa dos Recursos Hídricos (s. 1978)

Editorial Boards: Science of Tsunami Hazards (s. 1995)

Organizer - Scientific Meetings: Land-Margin Ecosystem and Processes topical session, Eastern Pacific Ocean Conference (EPOC), Timberline, OR (1996); 2nd Convection-Diffusion Forum, an activity of the VII Int. Conf. on Computational Methods in Water Resources, Boston, MA, USA (1988).

Scientific Advisory Committee - Conferences: 3rd Int. Conf. on Estuarine and Coastal Modeling, Chicago, IL, USA (1993); Int. Conf. on Computer Modeling of Seas and Coastal Regions, Southampton, England (1992); 2nd Int. Conf. on Estuarine and Coastal Modeling, Tampa Bay, FL, USA (1991)

Keynote Addresses: Int. Conf. on Education Practice and Promotion of Computational Methods in Engineering Using Small Computers, Macau (1995); Water Congress, Lisboa, Portugal (1994); Int. Conf. on the Pearl Harbor River Estuary, Macau (1992); Int. Conf. on Computer Modeling of Seas and Coastal Regions, Southampton, England (1992)

Some Representative Publications

Baptista, A.M., M. Wilkin, P. Pearson, P. Turner, C. McCandlish, P. Barrett, S. Das, W. Sommerfield, M. Qi, N. Nangia, D. Jay, D. Long, C. Pu, J. Hunt, Z. Yang, E. Myers, J. Darland and A. Farrenkop,. 1998. Towards a multi-purpose forecast system for the Columbia River estuary. Ocean Community Conference '98, Baltimore, Maryland. 6 pp.

Oliveira A. and A.M. Baptista. On the role of tracking on Eulerian-Lagrangian solutions of the transport equation, Advances in Water Resources (in press).

Fortunato A., A.M. Baptista and R. Luettich, 1997. Tidal dynamics in the mouth of the Tagus Estuary (Portugal), Continental Shelf Research, 17(14):1689-1714.

Oliveira A. and A.M. Baptista, 1997. Diagnostic modeling of residence times in estuaries, Water Resources Research, 33(8):1935-1946.

Fortunato A.B. and A.M. Baptista, 1996. Vertical discretization in tidal flow simulations. International Journal of Numerical Methods in Fluids, 22:815-834.

Baptista A.M., E.E. Adams and P. Gresho, 1995. Benchmarks for the transport equation: the convection-diffusion forum and beyond, Quantitative Skill Assessment for Coastal Ocean Models, Lynch & Davies (Eds.), AGU Coastal and Estuarine Studies, V. 47, pp. 241-268.

Wood T.M. and A.M. Baptista, 1993. A diagnostic model for estuarine geochemistry. Water Resources Research, 29(1):51-71.

Vita Sketch
Malcolm H. Karr
12/8/98

EDUCATION

BS in civil engineering, Oregon State University, 1953
MS in water resources management, University of Wisconsin, 1967

EMPLOYMENT HISTORY

Contractor with Columbia River Inter-Tribal Fish Commission since retirement in 1997.
Civil Engineer with Columbia River Inter-Tribal Fish Commission, 1980-97, including eight years with the Fish Passage Center of the Columbia Basin Fish and Wildlife Authority as Fish Passage Manager for the 13 Columbia Basin tribes.
Planning Director of the Pacific Northwest River Basins Commission, 1975-80.
Consultant to the Washington Legislative Committee on Water Resources in drafting Washington's Water Resources Act of 1971.
Manager of Land and Water Resources Planning at Battelle-Northwest, 1967-75.
Director of the Oregon State University Water Resources Research Institute, 1964-66.
Chief Engineer for the Oregon State Water Resources Board, 1957-64.

PROFESSIONAL STATUS

Professional Engineer, licensed in Oregon since 1959, in Washington since 1969.

CHRISTOPHER A. PEERY Ph.D.

EDUCATION

January 1991 – December 1995
College of Forestry, Wildlife and Range Sciences, Department of Fish and Wildlife Resources, University of Idaho, Moscow, ID 83844. Ph.D., Fisheries Resources.

September 1986 – August 1989
Virginia Institute of Marine Science, College of William and Mary, School of Marine Science, Gloucester Point, Virginia 23062. M.A., Biological Oceanography.

September 1982 – May 1986
Linfield College, McMinnville, Oregon. B.A., Biology.

RECENT EXPERIENCE

August 1996 – Present
Research Associate, Idaho Cooperative Fish and Wildlife Research Unit, University of Idaho, Moscow, Idaho 83844. Serving as project biologist on radio telemetry study to investigate passage conditions for adult chinook and sockeye salmon, steelhead and Pacific lamprey in the Columbia and Snake rivers, past dams and into tributaries.

January 1991 – December 1995
Ph.D. candidate, Department of Fish and Wildlife Resources, University of Idaho, Moscow, Idaho 83844.

March 1990 – December 1990
Research associate, Department of Fish and Wildlife Resources, University of Idaho, Moscow, Idaho 83844. Duties included compiling, reviewing, and writing a report on literature pertaining to adult salmonid passage over dams and through reservoirs.

RELEVENT PUBLICATIONS

Bjornn, T.C., K.R. Tolotti, and C.A. Peery. Migration rates of chinook salmon past lower Snake River dams through reservoirs, and in free-flowing rivers, 1991-1993. In preparation.

Bjornn, T.C., K.R. Tolotti, and C.A. Peery. Passage and survival of adult chinook salmon at Snake River dams and into tributary streams, 1991-1993. In preparation.

Bjornn, T.C., K.R. Tolotti, J.P. Hunt, P.J. Keniry, R.R. Ringe, and C.A. Peery. 1998. Migration of adult chinook salmon and steelhead past dams and through reservoirs in the lower Snake River and tributaries; Part 1, Passage of chinook salmon through the lower Snake River and distribution into the tributaries, 1991-1993. U.S. Army Corps of Engineers, Walla, Walla District. Final Report.

Bjornn, T.C., C.A. Peery, and K.R. Tolotti. 1998. Effects of spill on passage of steelhead at John Day Dam, 1997. Idaho Cooperative Fish and Wildlife Research Unit, University of Idaho, Moscow. Technical Report 98-6.

Bjornn, T.C., C.A. Peery, K.R. Tolotti, and M.A. Jepson. 1998. Evaluation of running turbine 1 at maximum capacity on passage of adult salmon and steelhead at John Day Dam, 1997. Idaho Cooperative Fish and Wildlife Research Unit, University of Idaho, Moscow. Technical Report 98-3.

Bjornn, T.C., M.A. Jepson, C.A. Peery, and K.R. Tolotti. 1997. Evaluation of adult chinook salmon passage at Priest Rapids Dam with orifice gates open and closed – 1996. Idaho Cooperative Fish and Wildlife Research Unit, University of Idaho, Moscow, Technical Report 97-1.

Bjornn, T.C., and C.A. Peery. 1992. A review of literature related to movements of adult salmon and steelhead past dams and through reservoirs in the lower Snake River. Idaho Cooperative Fish and Wildlife Research Unit, University of Idaho, Moscow, Technical Report 92-1, and U.S. Army Corps of Engineers, Walla Walla district, Final Report.

Peery, C.A., T.C. Bjornn, and K.R. Tolotti. 1998. Effects of a shad fishery on passage of adult chinook salmon through the Oregon-shore fishway ladder a The Dalles Dam – 1996. Idaho Cooperative Fish and Wildlife Research Unit, University of Idaho, Moscow. Technical Report 98-4.

Peery, C.A., T.C. Bjornn, and K.R. Tolotti. 1998. Evaluation of adult chinook and sockeye salmon passage at Priest Rapids and Wanapum dams – 1997. Idaho Cooperative Fish and Wildlife Research Unit, University of Idaho, Moscow. Technical Report 98-5.

Section 10. Information/technology transfer

One of the driving concepts of this project is to make temperature and fish movement data available to managers, researchers, and other interested parties as close to real time as possible via the Internet. A page located either on the Streamnet (www.streamnet.org) or CRITFC (www.critfc.org) web sites will provide general information on the project and project status. Links to web sites at Oregon Graduate Institute and the University of Idaho will be provided. At these sites, temperature and fish movement data will be available.

Models and data from the temperature monitoring network developed by this project will be available for use by managers and researchers throughout this project. The model and temperature monitoring network are both intended for use by fishery managers to optimize the cool water releases from Dworshak Dam subsequent to the completion of this project.

Annual workshops will be conducted each spring to give preliminary results, provide an opportunity for comments, and to allow model intercomparisons by participants. These workshops will also allow water managers, this project, and other researchers to coordinate their efforts. In Year 4, three focused workshops will promote, in a step-wise manner, the development of consensus planning for strategies that improve salmonid migration (see Methods, Task 4c).

Congratulations!